# CASE STUDY

Bartels mikrotechnik

with passion for microfluidics

## Enabling automated cell preparation by controlled volume dispensing

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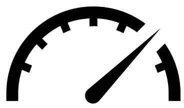
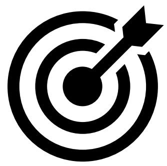


High throughput

Lab automation



Simple & precise dosing of reagents

**In the realm of modern laboratory research, the intricate process of cell preparation stands as a critical foundation for a myriad of scientific endeavors, from fundamental biological studies to advanced drug development and disease research. Historically a manual and often labor-intensive procedure, recent advancements in technology have introduced the concept of automated cell preparation through controlled volume dispensing. This innovative approach marries the precision of automated systems with the delicate intricacies of cell manipulation, promising not only to significantly enhance the efficiency of laboratory workflows but also to elevate the reproducibility and accuracy of experimental outcomes.**

**This approach not only ensures precision whilst handling liquid volumes on the microfluidic scale, but also stands out for its easy setup and use of readily available, off-the-shelf components. This case study delves into the streamlined process this automation offers, emphasizing its simplicity and the convenience of using a compact setup. Further making them great candidates for upscaling to high-throughput applications.**

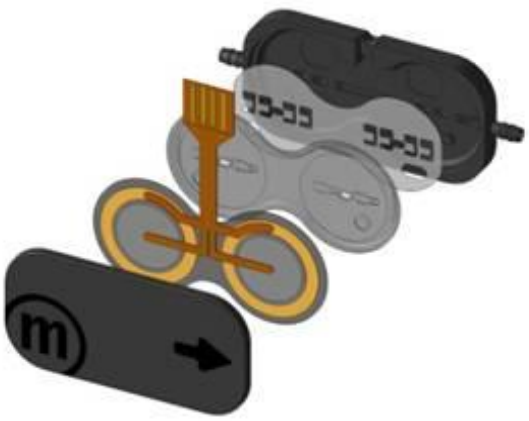
## What is microfluidics?

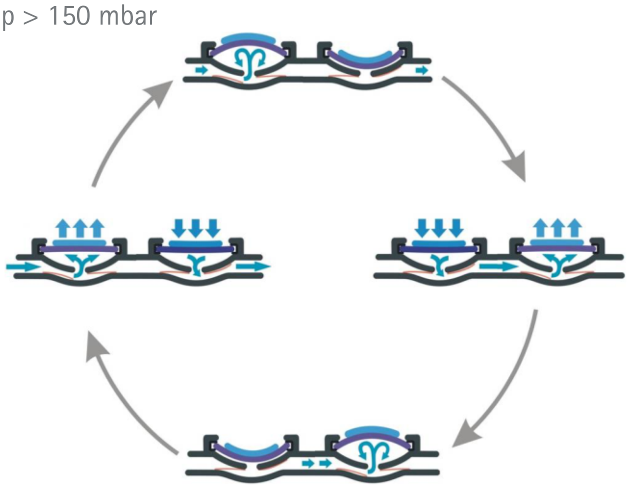
Microfluidics is the fine art of creation and manipulation of small portions of fluids, often realized by flow within small, sub-millimeter-scale channels. These small dimensions allow the fluid flow to be controlled with exquisite precision (Seifert, Thiele; 2020).

## About the mp6 micropump

The available, industrialized and commercialized example is the mp6 micropump by Bartels Mikrotechnik GmbH. This micro pump is a positive displacement membrane pump utilizing piezo actuators. The alternating displacement of the piezo acutators lead to the following typical fluidic values of the pump:

- Liquids (eta = 1 mPas): q = 5 - 8000 µl/min in free flow and p > 600 mbar
- Gas: q > 25 ml/min in free flow and p > 150 mbar





## Experimental Setup – Overview

For this case study, the following components are used to achieve controlled volume dispensing:

1. **Pump setup including driver unit**
   a. mp-Multiboard2 with Bartels regulation software Add-on
   b. mp6 micropump
   c. mp-Highdriver micropump driver

2. **Sensors**
   SLF3S-0600F liquid flow sensor by Sensirion AG

3. **Fluidic accessories like**
   a. Polymer nozzle with an ID of 150µm by AirLogic
   b. mp-damper
   c. mp-cv checkvalve
   d. mp-t (1,3 mm) Tubing

4. **Reagents in a reservoir**
   DI-water

For this application DI water is directly pumped by a mp6 micropump. In series with the pump is a liquid flow sensor for direct feedback of the conveyed volume. Between pump and sensor is a pulsation damper added to smoothen the pumps flow and achieve more accurate sensor readings. To prevent back flow due to gravimetric forces a checkvalve is added as well. To generate a continuous jet stream instead of drops a nozzle with small inner diameter is added at the pumps outlet connector. A scheme of the microfluidic setup is presented in Figure 1.

The mp6 micropump is controlled by the mp-Highdriver at pre-set parameters. With the Multiboard2 App the Flowcontrol type "Volume Dispensing" is selected. A target volume can be entered and the pump is automatically turned off after reaching it. The system tracks the dispensed volume by integrating the flowsensors readings over time.

Multiple jets are performed and dispensed volume is then measured by electronic scale. Target volumes are 1000 µl, 100 µl, 10 µl & 1 µl at two different sets of pump parameters. Additionally, the pumps dispensing time for each volume is measured.

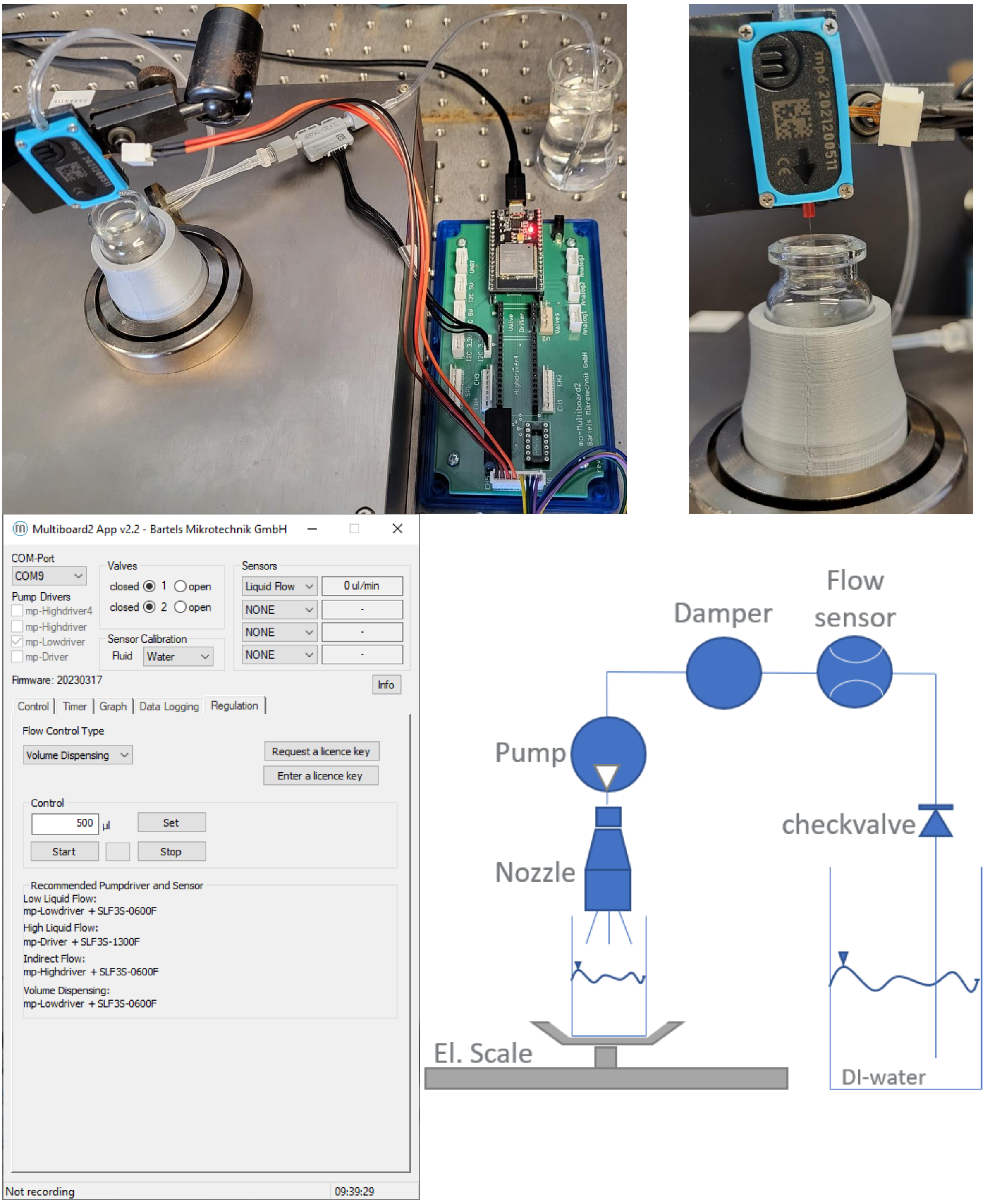



*Figure 1 Setup of the microfluidic system used for direct volume dispensing. Above: In real setup, Bottom left: Control via Multiboard2 APP on PC, Bottom right: Schematic*

## Experimental Results

*Table 1 Summary of measured volumes & deviations of the experimental setup by scale and dispensing time per volume with pump parameters set to 150Vpp, 50Hz, sinusoid signal shape*

| Target Volume [µl] | Mean Volume [µl] | Mean Volume deviation [µl] | % off of target | mean dispensing time [s] |
|---|---|---|---|---|
| 1000 | 1007,6 | 20,3 | 0,8% | 87,73 |
| 100 | 105,2 | 16,2 | 5,2% | 8,33 |
| 10 | 14,7 | 0,7 | 47,0% | 1,27 |
| 1 | 4,3 | 0,7 | 329,0% | 0,36 |

*Table 2 Summary of measured volumes & deviations of the experimental setup by scale and dispensing time per volume with pump parameters set to 250Vpp, 100Hz, sinusoid signal shape*

| Target Volume [µl] | Mean Volume [µl] | Mean Volume deviation [µl] | % off of target | mean dispensing time [s] |
|---|---|---|---|---|
| 1000 | 1007,8 | 26,5 | 0,8% | 24,80 |
| 100 | 106,5 | 4,8 | 6,5% | 2,77 |
| 10 | 16,9 | 3,1 | 69,4% | 0,61 |
| 1 | 15 | 4,7 | 1400,0% | 0,33 |

## Summary & Conclusion

The objective of this study was to investigate the performance of the mp6 micropump in volume dispensing applications, with particular focus on achieving precise volumes at microscale levels. The results indicate that the micropump is capable of reliably dispensing volumes of 1000 µl and 100 µl, meeting the target volumes with minimal error.

However, it is evident from the data that, aiming for volumes of 10 µl and below, the error in dispensing increases significantly. This suggests that there are challenges in achieving high precision at these lower volume ranges.

One possible explanation for this discrepancy may lie in the software used to integrate flowrate readings. It is likely that optimizations are needed in terms of shorter time stamps and a higher sampling rate to accurately capture the microscale flow dynamics. Additionally, the ramp-up and ramp-down of the flowrate may not be properly accounted for in the current software setup, as the portion of a steady and contiuous flow become maginal at the set flowrates. In the executed experiments flowrates of about 2400 µl/min (@250 Vpp & 100 Hz) and 700 µl/min (@150 Vpp & 50 Hz) were measured. Adjusting the pumps parameters to reduce the flowrate even further should increase accuracy at the cost of increasing dispensing time.

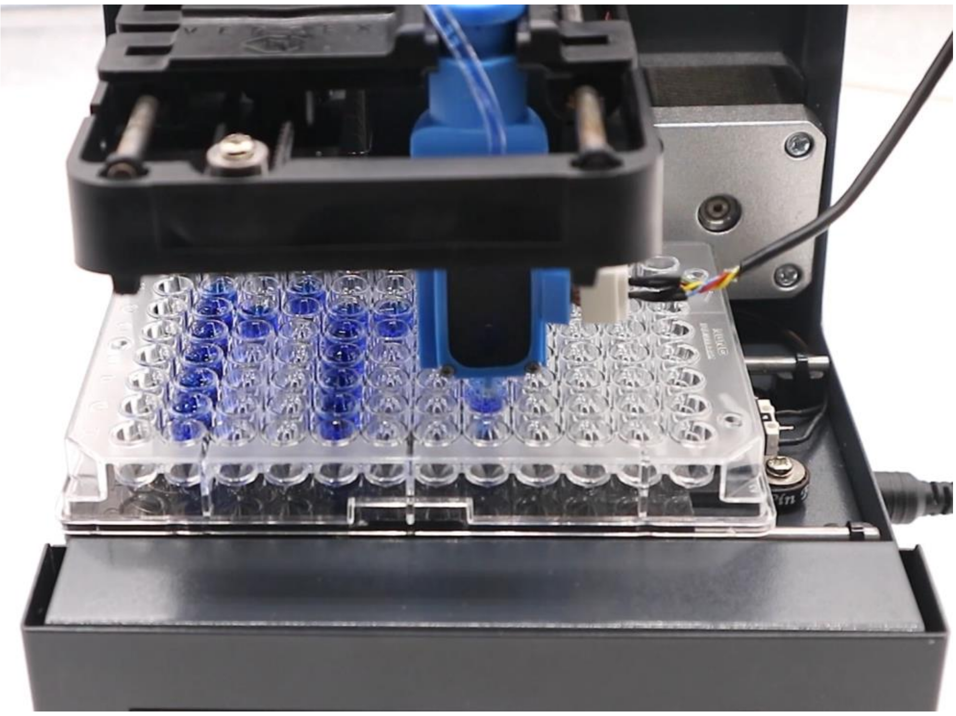
In conclusion, while the mp6 micropump demonstrates excellent performance in achieving target volumes of 1000 µl and 100 µl, further software optimizations and adjustments are necessary to improve precision at 10 µl and even lower ranges. These findings pave the way for continued research and development in microscale volume dispensing applications, with the potential to unlock even greater accuracy in the future.

## Outlook & Practical Showcase

To further enhance the precision of volume dosing with the mp6 micropump, software optimizations are in progress. These improvements will address microscale challenges, reducing errors for volumes of 10 µl and below.

We showcased the mp6 micropump's versatility by integrating it with a pick & place robot for automated well plate filling and cell culture sample preparation. Its small size and light weight make it an ideal choice for compact automated systems.

For a visual demonstration, watch our showcase video on YouTube:
https://www.youtube.com/watch?v=WdiGUPV8eVY



## Acknowledgement:

We would like to express our gratitude to AirLogic for their outstanding collaboration in providing a customized nozzle that seamlessly integrated with the mp6 micropump. Their dedication to precision engineering and commitment to excellence greatly enhanced the accuracy and efficiency of our dispensing process.

This case study would not have been possible without the unwavering support and expertise of AirLogic. We are truly thankful for their partnership and assistance in achieving our research objectives.

**Bartels Mikrotechnik** is a globally active manufacturer and development service provider in the field of microfluidics. In the microEngineering division, the company supports industrial customers in the modification, adaptation and new development of high-performance and market-oriented product solutions through the innovative means of microsystems technology. The second division, microComponents, produces and distributes microfluidic products and systems, especially for miniaturized and portable applications. Our key products are micropumps that convey smallest quantities of gases or liquids and are used in a variety of ways in biotechnology, pharmaceuticals, medical technology and numerous other applications.

**Bartels Mikrotechnik with passion for microfluidics!**

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